1. A method of plating a metal layer on a substrate, comprising the steps of:

providing a substrate;

forming a barrier layer on a top surface of the substrate;

forming a metal seed layer on the barrier layer by reacting the barrier layer with a first plating solution; and

forming a metal layer on the metal seed layer by exposing the substrate to a second plating solution.

2. The method of claim 1, wherein said barrier layer is a layer of material selected from the group consisting of titanium, titanium nitride, tantalum, tantalum nitride, tungsten nitride, tungsten-tantalum alloys, tantalum silicon nitride, and other ternary compounds.

3. The method of claim 1, wherein said metal seed layer forming step comprises immersing the substrate in the first plating solution.

4. The method of claim 1, wherein said metal seed layer forming step comprises spraying the first plating solution on the substrate.

5. The method of claim 1, wherein said metal seed layer forming step is an electroless plating step.

6. The method of claim 1, wherein said metal seed layer forming step is an electrolytic plating step.

7. The method of claim 1, wherein said metal layer forming step comprises immersing the substrate in the second plating solution.

8. The method of claim 1, wherein said metal layer forming step comprises spraying the second plating solution on the substrate.

9. The method of claim 1, wherein said metal layer forming step is an electroless plating step.

10. The method of claim 1, wherein said metal layer forming step is an electrolytic plating step.

11. The method of claim 1, wherein the first plating solution comprises a first aqueous solution of a first metal and a first acid, and the second plating solution comprises a second aqueous solution of a second metal and a second acid.

12. The method of claim 11, wherein the first and second metals are the same metal.

13. The method of claim 12, wherein the first and second metals are copper.

14. The method of claim 12, wherein the first and second aqueous solutions are the same.

15. The method of claim 11, wherein the first metal is a metal salt.

16. The method of claim 11, wherein the first metal is a metal complex.

17. The method of claim 11, wherein the second metal is a metal salt.

18. The method of claim 11, wherein the second metal is a metal complex.

19. The method of claim 11, wherein the first and second metals are different metals.

20. The method of claim 11, wherein the first and second metals are metals selected from the group consisting of nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, mercury and polonium.

21. The method of claim 11, wherein at least one of the first and the second metals is copper.

Sub B1

22. The method of claim 1, further comprising a step of forming a silicon-containing layer on a top surface of the barrier layer prior to the metal seed layer forming step.

23. The method of claim 22, wherein said silicon-containing layer forming step comprises oxidizing the substrate in an ozone-containing rinse bath.

24. The method of claim 22, wherein said silicon-containing layer forming step comprises deposition of the silicon-containing layer on the substrate.

25. The method of claim 22, wherein said silicon-containing layer is a layer of silicon dioxide.

27
~~26~~. A method of fabricating a conductive layer on a semiconductor substrate, comprising the steps of:

providing a semiconductor substrate;

forming a silicon layer on a top surface of the substrate;

forming a metal seed layer from the silicon layer by reacting the silicon layer with a first plating solution; and

forming a conductive layer on the metal seed layer by exposing the substrate to a second plating solution.

28 27
~~27~~. The method of claim ~~26~~, wherein said silicon layer forming step comprises oxidizing the substrate in an ozone-containing rinse bath.

29 27
~~28~~. The method of claim ~~26~~, wherein said silicon layer forming step comprises deposition of the silicon layer on the substrate.

17

30 27
~~29~~. The method of claim ~~26~~, wherein said silicon layer forming step further comprises forming a barrier layer on the top surface of the substrate and forming the silicon layer on the barrier layer.

31 27
~~30~~. The method of claim ~~26~~, wherein said metal seed layer forming step comprises immersing the substrate in the first plating solution.

32 27
~~31~~. The method of claim ~~26~~, wherein said metal seed layer forming step comprises spraying the first plating solution on the substrate.

33 27
~~32~~. The method of claim ~~26~~, wherein said metal seed layer forming step is an electroless plating step.

34 27
~~33~~. The method of claim ~~26~~, wherein said metal seed layer forming step is an electrolytic plating step.

35 27
~~34~~. The method of claim ~~26~~, wherein the first plating solution comprises a first aqueous solution of a first metal and a first acid, and the second plating solution comprises a second aqueous solution of a second metal and a second acid.

36 35
~~35~~. The method of claim ~~34~~, wherein the first and the second metals are the same metal.

37 36
~~36~~. The method of claim ~~35~~, wherein the first and second metals are copper.

38 36
~~37~~. The method of claim ~~35~~, wherein the first and the second aqueous solutions are the same.

39 35
~~38~~. The method of claim ~~34~~, wherein the first metal is a metal salt.

40 35
~~39~~. The method of claim ~~34~~, wherein the first metal is a metal complex.

41 35
~~40~~. The method of claim ~~34~~, wherein the second metal is a metal salt.

42 35
~~41~~. The method of claim ~~34~~, wherein the second metal is a metal complex.

43 35
~~42~~. The method of claim ~~34~~, wherein the first and second metals are different metals.

44 35
~~43~~. The method of claim ~~34~~, wherein the first and second metals are metals selected from the group consisting of nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, mercury and polonium.

45 35
~~44~~. The method of claim ~~34~~, wherein at least one of the first and the second metals is copper.

46 27
~~45~~. The method of claim ~~26~~, wherein said conductive layer forming step is an electroless plating step.

47 27
~~46~~. The method of claim ~~26~~, wherein said conductive layer forming step is an electrolytic plating step.

47. A method of forming a metal interconnect for a semiconductor circuit, comprising the steps of:

providing a semiconductor substrate having electronic devices formed thereon;

forming a barrier layer on a top surface of the substrate and the devices;

forming a metal seed layer on the barrier layer by reacting the barrier layer with a first plating solution; and

forming a metal interconnect layer on the metal seed layer by exposing the substrate to a second plating solution.

49 48
~~48~~. The method of claim ~~47~~, wherein said barrier layer forming step comprises chemical vapor deposition.

50 48
~~49~~. The method of claim ~~47~~, wherein said barrier layer forming step comprises physical vapor deposition.

50. The method of claim 47, wherein the barrier layer is a layer of material selected from the group consisting of titanium, titanium nitride, tantalum, tantalum nitride, tungsten nitride, tungsten-tantalum alloys, tantalum silicon nitride, and other ternary compounds.

52 48
~~51~~. The method of claim ~~47~~, wherein said metal seed layer forming step comprises immersing the substrate in the first plating solution.

53 48
~~52~~. The method of claim ~~47~~, wherein said metal seed layer forming step comprises spraying the first plating solution on the substrate.

54 48
~~53~~. The method of claim ~~47~~, wherein said metal seed layer forming step is an electroless plating step.

55 48
~~54~~. The method of claim ~~47~~, wherein said metal seed layer forming step is an electrolytic plating step.

56 48
~~55~~. The method of claim ~~47~~, wherein said metal interconnect layer forming step comprises immersing the substrate in the second plating solution.

57 48
~~56~~. The method of claim ~~47~~, wherein said metal interconnect layer forming step comprises spraying the second plating solution on the substrate.

48 48
~~57~~. The method of claim ~~47~~, wherein said metal interconnect layer forming step is an electroless plating step.

59 48
~~58~~. The method of claim ~~47~~, wherein said metal interconnect layer forming step is an electrolytic plating step.

60
~~59~~. The method of claim 47, wherein the first plating solution comprises a first aqueous solution of a first metal and a first acid, and the second plating solution comprises a second aqueous solution of a second metal and a second acid.

61
~~60~~. The method of claim 59, wherein the first and second metals are the same metal.

62
~~61~~. The method of claim 60, wherein the first and second metals are copper.

63
~~62~~. The method of claim 60, wherein the first and second aqueous solutions are the same.

64
~~63~~. The method of claim 60, wherein the first metal is a metal salt.

65
~~64~~. The method of claim 60, wherein the first metal is a metal complex.

66
~~65~~. The method of claim 60, wherein the second metal is a metal salt.

67
~~66~~. The method of claim 60, wherein the second metal is a metal complex.

68
~~67~~. The method of claim 59, wherein the first and second metals are different metals.

~~68~~ 69. The method of claim ~~59~~ 60, wherein the first and second metals are metals selected from the group consisting of nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, mercury and polonium.

~~69~~ 70. The method of claim ~~59~~ 60, wherein at least one of the first and the second metals is copper.

Sub B3 ~~70. The method of claim 47, further comprising a step of forming a silicon layer on a top surface of the barrier layer prior to the metal seed layer forming step.~~

~~71~~ 72. The method of claim ~~70~~ 71, wherein said silicon layer forming step comprises oxidizing the substrate in an ozone-containing rinse bath.

~~72~~ 73. The method of claim ~~70~~ 71, wherein said silicon layer forming step comprises deposition of the silicon layer on the substrate.

~~73~~ 74. The method of claim ~~70~~ 71, wherein the silicon layer is a layer of silicon dioxide.

~~74~~ 75. The method of claim ~~70~~ 71, wherein the silicon layer is a layer of silicon monoxide.

23

177
~~75.~~ A method of forming a metal interconnect for a semiconductor circuit, comprising the steps of:

providing a semiconductor substrate having electronic devices formed thereon;

forming a silicon oxide layer on a top surface of the substrate and the devices;

forming a metal seed layer from the silicon oxide layer by reacting the silicon oxide layer with a first plating solution containing a first metal; and

forming a metal interconnect layer on the metal seed layer by exposing the substrate to a second plating solution containing a second metal.

178 177
~~76.~~ The method of claim ~~75~~, wherein said silicon oxide layer forming step comprises oxidizing the substrate in an ozone-containing rinse bath.

179 177
~~77.~~ The method of claim ~~75~~, wherein said silicon oxide layer forming step comprises deposition of the silicon oxide layer on the substrate.

186 177
~~78.~~ The method of claim ~~75~~, wherein the silicon oxide layer has a thickness within the range of approximately 10 to 200 Angstroms.

181 177
~~79.~~ The method of claim ~~75~~, wherein the silicon oxide layer has a thickness within the range of approximately 10 to 50 Angstroms.

182 177
~~80.~~ The method of claim ~~75~~, wherein said silicon oxide layer is a layer of silicon dioxide.

24

83 77
~~81~~. The method of claim ~~75~~, wherein said silicon oxide layer forming step further comprises forming a barrier layer on the top surface of the substrate and forming the silicon oxide layer on the barrier layer.

82. The method of claim 81, wherein the barrier layer is a layer of material selected from the group consisting of titanium, titanium nitride, tantalum, tantalum nitride, tungsten nitride, tungsten-tantalum alloys, tantalum silicon nitride, and other ternary compounds.

86 77
~~83~~. The method of claim ~~75~~, wherein said metal seed layer forming step comprises immersing the substrate in the first plating solution.

87 77
~~84~~. The method of claim ~~75~~, wherein said metal seed layer forming step comprises spraying the first plating solution on the substrate.

88 77
~~85~~. The method of claim ~~75~~, wherein said metal seed layer forming step is an electroless plating step.

89 77
~~86~~. The method of claim ~~75~~, wherein said metal seed layer forming step is an electrolytic plating step.

90 77
~~87~~. The method of claim ~~75~~, wherein the first metal is copper.

91 90
~~88~~. The method of claim ~~87~~, wherein the first plating solution is an aqueous solution of copper sulfate and hydrofluoric acid.

92 92 77
~~89~~. The method of claim ~~75~~, wherein said metal interconnect layer forming step comprises immersing the substrate in the second plating solution.

93 77
~~90~~. The method of claim ~~75~~, wherein said metal interconnect layer forming step comprises spraying the second plating solution on the substrate.

94 77
~~91~~. The method of claim ~~75~~, wherein said metal interconnect layer forming step is an electroless plating step.

95 77
~~92~~. The method of claim ~~75~~, wherein said metal interconnect layer forming step is an electrolytic plating step.

96 77
~~93~~. The method of claim ~~75~~, wherein the second metal is copper.

97 96
~~94~~. The method of claim ~~93~~, wherein the second plating solution is an aqueous solution of copper sulfate and hydrofluoric acid.

98 77
~~95~~. The method of claim ~~75~~, wherein the first and second metals are selected from the group consisting of nickel, copper, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, gold, mercury and polonium.

99
96. A method of plating copper onto a substrate, comprising the steps of:

providing a substrate;

forming a barrier layer on a top surface of the substrate;

forming a silicon oxide layer on the barrier layer;

forming a copper seed layer from the silicon oxide layer by reacting the silicon oxide layer with a plating solution containing copper and an acid; and

forming a copper layer on the copper seed layer by exposing the substrate to the plating solution for a time sufficient to produce a desired thickness of the copper layer.

100 99
97. The method of claim 96, wherein the silicon oxide layer is a layer of silicon dioxide.

101 99
98. The method of claim 96, wherein the silicon oxide layer has a thickness within the range of approximately 10 to 200 Angstroms.

102 99
99. The method of claim 96, wherein the silicon oxide layer has a thickness within the range of approximately 10 to 50 Angstroms.

100. The method of claim 96, wherein the barrier layer is a layer of material selected from the group consisting of titanium, titanium nitride, tantalum, tantalum nitride, tungsten nitride, tungsten-tantalum alloys, tantalum silicon nitride, and other ternary compounds.

104 99
~~101~~. The method of claim ~~96~~, wherein the barrier layer has a thickness within the range of 50 to 500 Angstroms.

105 99
~~102~~. The method of claim ~~96~~, wherein the barrier layer has a thickness of approximately 300 Angstroms.

106 99
~~103~~. The method of claim ~~96~~, wherein the plating solution contains a copper salt.

107 106
~~104~~. The method of claim ~~103~~, wherein the acid is sulfuric acid.

108 106
~~105~~. The method of claim ~~103~~, wherein the plating solution comprises an aqueous solution of copper sulfate and hydrofluoric acid.

109 108
~~106~~. The method of claim ~~105~~, wherein the plating solution comprises approximately 3 grams of copper sulfate per liter of plating solution.

110 99
~~107~~. The method of claim ~~96~~, wherein the plating solution contains a copper complex.

111 99
~~108~~. The method of claim ~~96~~, wherein the plating solution comprises approximately 1 part hydrofluoric acid per 100 parts water.

112 99
~~109~~. The method of claim ~~96~~, wherein said copper seed layer forming step is an electroless plating step.

113 99
~~110~~. The method of claim ~~96~~, wherein said copper layer forming step is an electrolytic plating step.

115
~~111~~. A method of forming a copper interconnect for a semiconductor circuit, comprising the steps of:

providing a semiconductor substrate having devices formed thereon;

forming a barrier layer on a top surface of the substrate and the devices, wherein the barrier layer has a thickness of approximately 50 to 500 Angstroms;

forming a silicon dioxide layer on the barrier layer, wherein the silicon dioxide layer has a thickness of approximately 10 to 200 Angstroms;

forming a copper seed layer from the silicon dioxide layer by reacting the silicon dioxide layer with a plating solution containing copper sulfate and dilute hydrofluoric acid; and

forming a copper layer on the copper seed layer by exposing the substrate to the plating solution for a time sufficient to produce a desired thickness of the copper layer.

Add A6